CALIFORNIA ENERGY COMMISSION

GUIDEBOOK for Combined Heat & Power

(REPORT DATE: SEPTEMBER, 1999)

CONSULTANT REPORT

OCTOBER 2000
P700-00-011

Gray Davis, *Governor*

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Guidebook for Combined Heat and Power

November 1999

Combined Heat and Power Frequently Asked Questions (CHP FAQ)

What is Combined Heat and Power?

Traditionally, electricity has been produced by power plants that burn fuel to drive electric generators. These power plants create a large amount of heat wasted in the process of producing electricity. This unused energy may equal up to 67% of the energy content of the fuel in a typical power plant.

In the past, industries that needed large amounts of steam heat in their manufacturing processes such as pulp and paper mills, petroleum producers and food processors had two choices. They could make steam on-site burning fuel in a boiler and provide their electricity needs separately through the local utility. This has been called separate heat and power. Or they could generate electricity on-site and use the waste heat from that process to create steam. Providing both electric power and heat from a single source is called combined heat and power (CHP), also known as cogeneration. While separate heat and power systems are often only 33% efficient (67% of the fuel energy is wasted), CHP can be 60% to 90% efficient by capturing and making productive use of the waste heat on-site.

There are many valuable uses for waste heat. Food processors need steam to can fruits and vegetables; commercial laundries use hot water for washing; health clubs heat water for swimming pools, showers, whirlpools and saunas. CHP can also serve facilities that need cooling or refrigeration by using the heat to drive modern heat absorption chiller and refrigeration technologies.

CHP technologies include diesel engines, natural gas engines, steam turbines, gas turbines, micro-turbines and fuel cells. Most are available for both CHP configurations and electric power generation alone. Some of the newest electric generating plants capture waste heat for use in creating more electricity. These combined cycle plants are highly efficient, but are not included in the definition of CHP because they do not serve an end-use thermal need. (Examples of CHP technologies are included within this Guidebook.)

Why is there new interest in CHP?

In 1978 the US congress passed the Public Utilities Regulatory Policy Act (PURPA) requiring electric utilities to interconnnect with CHP and small renewable power sources and buy electricity from these sources at their avoided costs. This encouraged many large industrial customers to install CHP, interconnect to the utility grid, and sell power to the local utility. PURPA no longer provides sufficient incentive to install CHP and as a result the rate of new installations has dropped. *(See "The Decline and Fall of Cogeneration", p2.)*

There is a resurgence of interest in CHP, for

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CHP FAQ

many reasons:

- The turbine and engine manufacturers have significantly improved CHP technologies by increasing energy efficiencies, reducing maintenance costs and increasing engine reliability.
- Policy makers have recognized that CHP can meet the power and steam needs of industry while burning 35% to 40% less fossil fuel, thus there is a significant reduction in emissions of greenhouse gases that contribute to global warming.
- Higher energy efficiency and improved combination technologies are leading to cleaner burning engines and reducing electric power production contribution to regional and local air pollution levels.
- On-site power systems such as CHP take pressure off transmission systems and reduce line losses related to the long distance delivery of electricity.
- As the gas and electric industries open up to competition, customers are in a better position than ever to install CHP and take advantage of its cost-saving benefits.

The Department of Energy (DOE), the Environmental Protection Agency (EPA) and the California Energy Commission (Commission) are actively pursuing policies in support of combined heat and power.

How important is CHP to California?

Because CHP increases overall fuel efficiency in many commercial, industrial and institutional processes, it provides energy and environmental benefits unattainable through the use of separate heat and power. These benefits can be used as tools for environmental and energy policy implementation by California policy makers and to enhance the competitive advantages of California business. The following describes the value of California CHP in greater detail.

High Energy Efficiency

The primary benefit of CHP is improved energy efficiency. "Energy efficiency" means less fuel is used to produce a given amount of useful energy. CHP improves energy efficiency by using waste heat to address thermal energy needs on-site. Even the most modern combined-cycle natural gas-fired power plants achieve no more than 60% energy efficiency. As impressive as this achievement is, CHP can achieve overall energy efficiencies of 80% or higher. CHP also saves on electricity line losses compared to delivering electricity to a distant location. Line Losses are typically 4% to 10% of the electricity produced at a distant location.

Decline and Fall of Cogen

The growth rate of cogeneration, the traditional name for CHP, rose and fell in California with the fortunes of PURPA. Before 1978, when the federal legislation was passed, there were only nine cogeneration units existed in the state. By 1988, 380 more cogeneration plants were built; 270 were added by 1997. The growth rate for cogeneration has dropped in the 1990's, and the cumulative capacity has leveled off. CHP capacity installed in California is currently 6457 MW, about 12% of the forecast electric capacity demand in the state for the year 2000.

Before PURPA – The early industrial need for steam and electricity among certain energy intensive industries, such as pulp and paper mills, chemical plants and oil refineries, drove the pre-1970's market.

Rise of PURPA – PURPA was enacted to increase energy conservation and to diversify fuel resources. It stimulated the independent power market by requiring utilities to interconnect with Qualifying Facilities (QFs), CHP systems that recover more than 5% total useful heat, to provide backup power at reasonable rates and to purchase any excess electricity at the same rate the utilities would have had to pay to generate it themselves. PURPA fostered a dynamic CHP industry in California from the mid-1980's to the early 1990's. About 81% of existing California CHP capacity began operation during the decade after 1982.

Decline of PURPA – Then in the 1990's utility avoided costs, which had been forecast to increase, rapidly declined. QF contracts had been paid at fixed avoided cost levels forecast in 1983. In fact, avoided costs in

(continued on page 4)

CHP FAQ

There are 6457 MW of CHP in California today. Savings from avoided transmission and distribution losses amount to over 1.5 million MWh per year due to the location of CHP on the site where the electricity is used. By adding the avoided line losses and the generation of the CHP plants, the total combustion of CHP electricity to California is 40 million MWh, about 15% of the total electricity demand estimated for the year 2000.

The estimated total net energy savings from existing CHP in the state is about 7% of the forecast for energy to be consumed for electricity production in the year 2000. In other words, California would use 7% more energy to produce today's electricity if no CHP were on the system. The addition of more CHP in the system would increase this percentage of energy savings.

Customer cost savings

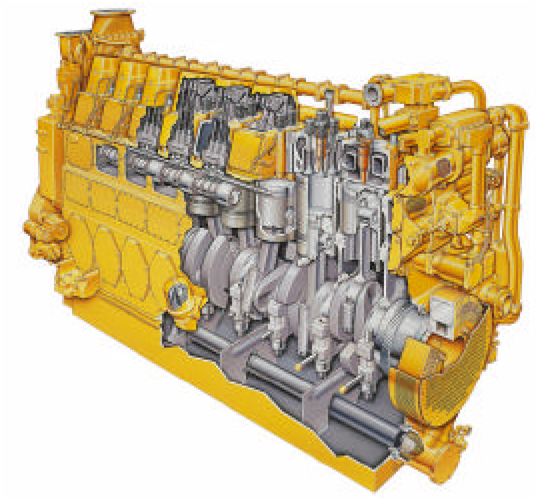
Many different charges are included in the rate a customer pays to a utility for the generation and delivery of electricity—energy charges, transmission and distribution charges, customer service charges and "public goods" charges which fund incentives for low-income, energy efficiency, energy research and renewable energy production. Most customers of California's largest utilities now pay electric rates that are higher than 85% to 90% of all customers in the nation—close to $0.12/kWh for residential and commercial customers and $0.04 to $0.09/kWh for large industrial customers. The Commission believes rates will decline after 2001 when utility stranded assets are paid off (see sidebar on "Electricity Restructuring", p.6). Commercial customers may pay $0.06 to $0.08/kWh and large industrial customers may pay $0.04 to $0.05/kWh.

Compare those electric rates to a well-designed industrial or large commercial CHP system that is continuously operated and which takes advantage of most of the waste heat—such a system can produce power for about $0.03 to $0.045/kWh. These costs include all capital and operating costs and apply the fuel savings due to use of the thermal energy use as a credit against the generated electricity price. It is possible that improvements to CHP technology and the adoption of policies to streamline the siting and installation of CHP units could bring these costs down to $0.025 to $0.036/kWh in the near future. These prices compete favorably with the forecast price of utility system power.

Cost savings from existing CHP in California can be estimated by determining the difference between the retail price of electricity and the CHP cost to generate electricity (including the fuel cost credit received for reducing their fuel use to operate a separate boiler). This calculation shows that California CHP customers save $580 million each year.

Outage protection and other features of CHP

Customers enjoy many benefits from CHP and other forms of on-site power production. Some customers value the protection from utility service outages and the ability to choose electricity or gas supplies depending on prevailing market prices. Others seek to avoid the highest utility



Advanced materials and manufacturing means lower initial costs, operating costs, emissions and size.

Caterpillar Internal Combustion Engines

Source: Caterpillar

CHP FAQ

prices by peak-shaving with their own generation or choosing a utility tariff that discounts electricity prices in exchange for giving the utility the right to interrupt service in an emergency. Some California industries require continuous, high quality electric service for computer operations in manufacturing plants.

The value of these benefits to each customer will depend on the characteristics of the facility, the kind and amount of energy it uses, the load profile, the rate tariffs, market prices of electricity and gas and other factors. Each customer making a CHP purchase decision must evaluate these and other benefits, including new revenues that may come from operation in the newly restructured electricity market.

Air Emissions Reductions

By increasing the efficiency of energy use, CHP reduces local air pollutants such as NOx and SO_2 and global greenhouse gases such as CO_2, for each unit of power produced. For this reason, the EPA has identified CHP technologies as leading candidates for reducing global CO_2 emissions and thus reducing the threat of global warming. In addition, advocates promote CHP as a cost-effective way to reduce local air quality impacts while helping to retain industry in California

The environmental benefits of CHP are difficult to calculate because the location of a new CHP plant in one region may lead to a reduction in power plant emissions in another distant region. Eliminating a ton of NOx in the Mojave Desert is not as valuable as eliminating a ton of NOx in Los Angeles. For this reason, NOx reductions in other states occurring as a result of California CHP are not included in this estimate of emission reductions. But while NOx is a regional problem of great concern to urban areas, CO_2 has worldwide impacts as a significant contributor to global warming. For this reason, we include out-of-state CO_2 reduction is included in this calculation of benefits. In total, existing CHP systems in California provides NOx reductions of almost 7000 tons per year and CO_2 reductions over 11 million tons annually.

Electric System Benefits

CHP and other types of on-site generation can offer grid support to the local distribution utility. This means that a utility could defer, or avoid altogether, an upgrade to the distribution system where the local CHP generation reduces the need for transfer capacity in those lines. This could save money for the utility as well as improve system reliability. Other benefits that generators provide to keep the electricity network stable include voltage and frequency

Decline and Fall of Cogen

California dropped from \$0.04 to \$0.07/kWh to approximately \$0.025/kWh, mainly due to low natural gas prices and improved technologies for natural gas fired generating stations. California's investor-owned utilities (IOUs) brought political pressure against the high prices paid to developers of QFs, and ultimately caused the decline of new QF contracts.

Oversupply of generating capacity gave utilities room to negotiate deferral rates with customers planning to install CHP. These low rates kept the customer on the utility system to help pay for some of the fixed costs of the excess capacity. Stable or declining utility system costs have made some customers more reluctant to take on the complexity of owning and operating a generation plant. In 1998, after nearly sixteen years of double-digit plant additions, only one cogeneration plant was built.

CHP Rises – There are two changes that are the basis of optimism for the future of CHP. First, there have been technological improvements to increase efficiencies and reduce environmental impacts from existing CHP technologies. Technologies are now available for the very smallest and the very largest customers. Second, California has restructured the electricity generation business. Customers now have a choice of suppliers, or they can supply themselves. The success of CHP in the California restructured market depends on whether the installed cost of the CHP technologies provides lower overall energy costs than the customer is paying currently. If CHP can provide its many benefits at a reasonable cost, it may rise again. ♦

support, reactive power control, and reduced central station generating reserve requirements.

Electric industry policy-makers are investigating the value of the grid support and other reliability services that come from installing CHP and other on-site generating plants. This information may help justify new utility tariffs that give credit to on-site generators for these benefits.

What are the barriers to more CHP in California?

An end-user considering CHP or other forms of on-site generation faces a number of market and regulatory hurdles, including utility rules and rate designs that discourage on-site generation, and complex environmental permitting and siting processes that cause project delays and increase project expenses. The following issues should be considered as part of the decision whether to install CHP.

Interconnection Barriers

California utilities are concerned about potential impacts on the electricity network from increased deployment of CHP. Since distribution systems were generally designed under the assumption that energy would flow only one direction from the utility to the customer, the generation components at the customer sites may cause the system to become electrically unstable. Utilities are also concerned about worker safety and the ability to isolate and de-energize distribution lines during repairs and system maintenance.

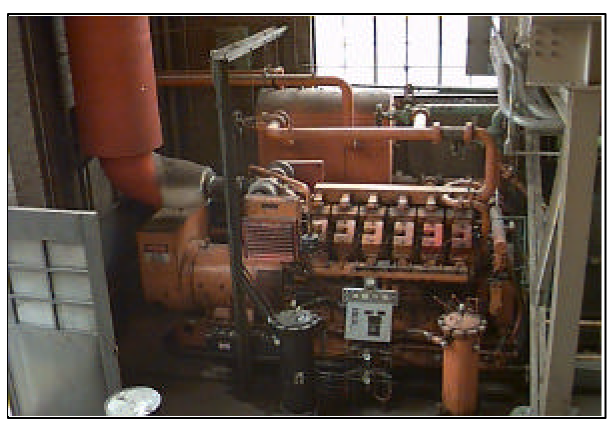
To address these concerns, utilities require interconnection studies to look at the local distribution system and determine the protection required for a specific technology at the specific location. Costs for studies depend on the voltage of the project and many other factors. Utilities currently have no incentive for making these studies quicker or less expensive. The cost of the study and the cost of the protection that the utility may require may make a cost-effective project infeasible. These interconnection requirements can be especially burdensome to systems less than 1 MW.

Interconnection requirements vary by utility and are often not based on state-of-the-art technology or data. Non-standard requirements make it difficult for equipment manufacturers to design and produce modular, pre-approved packages and to realize economies of scale. For these reasons, many proponents of CHP believe that non-standard, out-dated and overly stringent interconnection requirements are a significant barrier to widespread deployment of CHP and other types of on-site generation.

Standby and Back-up Charges

A customer with on-site CHP usually requires standby power from the local utility in case of on-site generation outages or routine system maintenance. A customer must pay the utility for the capacity and energy supplied in such circumstances (backup energy) as well as the on-going cost of maintaining the transmission and distribution system and the cost of having sufficient generation capability for the backup service (facilities demand charges.)

Some CHP proponents suggest that facilities demand charges for on-site generators are too high. All utility customers, whether they generate power on-site or not, pay rates based on their assumed pattern of use during peak periods. The rate assumes all customers have equally high energy demands during the system peak. However, CHP customers, unlike non-generating customers, are not likely to demand energy from the system coincidentally during the system peak. For example, if there are 100 CHP facilities



1 MW Compression Ignition Engine

CHP FAQ

averaging 1 MW each in capacity, and each is capable of running 90% of the time during the year, then it is likely that only 10% of the systems would require back-up energy during the system peak. So the real impact of the 100 systems is to add a requirement of only 10 MW to the system. Under the current standby rates, they are paying standby rates based on a full 100 MW share of the system.

Environmental Barriers

CHP provides many air quality benefits, but the most notable environmental barrier for CHP is the air quality permitting process.

The process can be long, complex and costly. The complexity results from differing regulatory requirements of the various air quality districts in the state. For example, air districts that exceed established ozone standards have more stringent permitting requirements, as well as source specific requirements, compared to the requirements of districts that meet the ozone standards. The time to obtain a permit can be long if the installation must be evaluated under stringent New Source Review (NSR) rules. In addition, demonstrating that a type of emissions control technology is not feasible or not cost-effective can lead to lengthy negotiations with the local air district, as well as oversight from state and federal agencies.

The high cost of air quality permitting not only stems from the lengthy permitting process but the potential need to install expensive emissions controls and/or purchase "emission reduction credits" (ERCs) to offset emissions. For example, with respect to gas turbines, the same type of controls and emission standards are imposed on the smaller units as are imposed on much larger turbines, even though these costs are a significant burden to smaller systems. In addition, a requirement to purchase ERCs can be avoided if the CHP unit is replacing an existing boiler, but a brand new installation may have to purchase local ERCs on the open market where low supplies and intense competition may drive up the price.

Finally, CHP air quality benefits are not accounted for in the permitting process. The emission reductions from displaced utility generation are not credited, nor is the local boiler displacement given credit except possibly NSR offsets. The allowable pollution emission standards are calculated as a volumetric "parts per million" rate or a "pounds per million Btu" at maximum fuel input rather than a "pounds per megawatt-hour" output-based rate. Thus the air quality regulators do not accredit the energy efficiency value of the generation. CHP proponents argue that the EPA should adopt rules that focus on the total

Industry Restructuring

Since March 31, 1998 most electric customers in California have had the right to purchase electricity from non-utility Energy Service Providers. Policy makers hope that competition for energy supplies will lead to lower prices, efficient investment in new power plants and more innovation in the delivery of energy services.

Assembly Bill (AB) 1890, the major piece of legislation for industry restructuring, created a new structure for the delivery of electricity in the state. A new Independent System Operator (ISO) now manages the transmission system while the local utility distribution companies (UDCs) manage the local distribution network. A Power Exchange (PX) acts as a market clearinghouse for the buying and selling of electricity in the new market.

The restructuring legislation and the regulations arising from the AB1890 is extraordinarily complex. Three aspects of restructuring influence the CHP market.

1. Sale of Utility Generation

Utilities have been encouraged to sell at least 50% of their generation assets in order to reduce their ability to exercise market power. Many large plants have been purchased by new owners, and the new owners may modify the units to operate more efficiently. As non-utility owners, they will operate the plants to maximize profits on energy sales, not to obtain a fair rate of return under a managed regulatory regime.

2. Stranded Asset Recovery

Under AB 1890, utilities are allowed to recover the costs of their stranded assets, those past investments that are uneconomic in the new competitive market. (Most stranded costs are related to nuclear

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mass of emissions per unit of energy produced, that is, output-based standards for generation air quality permitting.

Siting Barriers

CHP installations at commercial, industrial and especially residential locations may require permits from local the fire departments, building departments, planning departments, and air quality districts. Any CHP installation over 50MW must apply for siting review by the Commission.

Most local government rules are based on legitimate land-use and safety concerns. Fire departments must ensure that there are no fire and safety hazards with installation of small generating units in common places such as shopping centers and other public spaces. When CHP equipment must use air pollution control technology, hazardous materials (e.g., ammonia, sulfuric acid) may be involved. Additional approvals are needed to ensure on-site safety, proper handling and transport of hazardous materials.

In residential and many commercial areas, a local planning department may be concerned about noise and visual aesthetics. Other land use issues arise if the site is close to schools, hospitals, day care centers and environmentally sensitive areas. A CHP installation may require zoning amendments if a proposed site is not properly zoned. This can take time and could be unsuccessful without community understanding and acceptance.

What is the future of CHP in California?

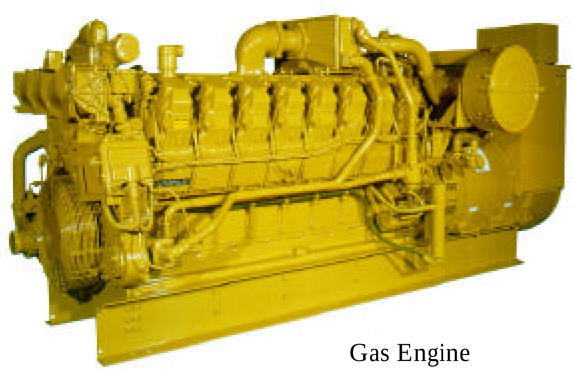
California became the largest market for CHP in the United States during the 1980's due to very high utility prices and beneficial power sale contracts under PURPA. This CHP boom period ended when environmental rules tightened and utilities began to offer lower prices to customers in exchange for their agreement to defer or cancel plans to install CHP. Many CHP developers abandoned the market when it became obvious that customer interest in CHP was often only a ploy to extract lower prices from the local utility.

The outlook for CHP in California depends on many marketplace factors. The single most important factor is the utility system price of electricity in the future. Industry restructuring is expected to lower the average commercial and industrial electric prices when CTC is paid off and the current rate freeze ends. According to a Commission forecast, the average retail commercial costs will drop to $0.062/kWh and industrial costs will drop to $0.048/kWh. These lower prices will be in line with current prices in some other states. In those low-cost states, CHP often has a hard time competing with utility system power supplies.

The DOE has initiated a "CHP Challenge" program with the goal of doubling CHP deployment in the nation by the year 2010. In order for California to achieve the goal of the CHP Challenge, 6457 additional MW will have to be built by 2010. The Commission, through a

Microengine

From the 5kW gas microengine (left) to the 2 MW spark ignition engine (below), internal combustion engines dominate the small - size CHP applications.



Gas Engine

CHP FAQ

DOE grant, has researched the projected market for CHP in the next 10 years. The study looked at the total potential market for CHP and estimated the amount of CHP that would be installed under various market and regulatory scenarios. Some of the key findings are summarized here.

Market Assessment Findings

If electricity prices decline as forecast, CHP technology does not improve, and no CHP market development policies are adopted, CHP installations are expected to decline over time. In this business-as-usual case, 4009 MW of additional CHP capacity would be installed by 2017. This does not meet the CHP Challenge goal at seven years past the deadline date of 2010. The case shows over 90% of the 4000 MW of capacity will come from the largest industrial size category of 20 MW and above, which will continue to be attractive economically. However, systems under 1 MW would be less than 1% of the total due to the high market barriers to small system development.

Some of the market development policies and the technology improvements described in this guidebook could significantly improve the outlook for CHP. The following improvements were considered in the study:

- *CHP technology improvement* – This includes efficiency improvements, package cost reductions, and reductions in environmental control technology costs that will be the result of expanded research, development and demonstration programs.
- *Streamlined Project Implementation* – This includes faster project implementation, lower interconnect costs from standardization, abbreviated permitting processes for lower financial carrying costs, and lower installation costs due to a more stable and competitive market for CHP.
- *CHP Initiatives* – Financial incentives provided by either the Federal or State government are being discussed for CHP. The rationale for these incentives is that increased penetration of economically viable CHP has both private benefits that accrue to the project participants and social benefits that accrue to the public.
- *Higher marketing effort* – The competitive market has created a larger number of energy service providers that will be contacting customers and marketing energy service options including CHP. With higher marketing effort, market penetration rates will be higher, customer confidence will increase, and customers will more readily adopt CHP alternatives.

Market Assessment Study Conclusions

The study concludes that the CHP technology

Industry Restructuring

power and high-priced PURPA contracts). Stranded costs are recovered through a Competition Transition Charge (CTC). Customers who choose to generate their own electricity cannot bypass the CTC unless a specific exemption applies. No CTC will apply to CHP systems that become operational after June 2000.

3. Public Purpose Programs

Public purpose programs, such as energy efficiency, renewable energy sources and energy research continue to be funded under AB1890. Control of the funds generated by the public goods charge ($201 million in 1998) lies with a new entity called the California Board of Energy Efficiency. The energy efficiency funds do not reward CHP projects directly. The indirect potential benefit to CHP from the public interest funds is through energy research.

Restructured Market and CHP

Most of California's utility power plants are now, or will soon be, in the hands of private owners who plan to produce power as cheaply as possible and sell it at a profit through the PX or directly to customers. There is a dynamic wholesale market for power in the western United States, and increasing demands for electricity in California may be met by new merchant power plants or on-site generation. The Commission has received siting applications for over 14,000 MW of new natural gas-fired power plants.

Competition in the wholesale markets and the addition of new, efficient generation in the state may reduce prices paid by large industrial customers and thus decrease the value of power generated on-site. Large CHP installations that depend on sales

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improvement alone could increase CHP penetration by 66MW. Adding “CHP Initiatives” and “Streamlined Project Implementation” to the improved technology would increase market penetration by 2134 MW. In the best case scenario, with all the above market improvements and higher marketing effort, CHP market penetration could reach 8,889 MW—an increase of 4880 MW over the business-as-usual case.

It is noteworthy that in the best case scenario, the market penetration for the smallest sizes of CHP would increase from less than 1% to nearly 18%. This increase represents almost 5000 small systems with a combined capacity of just under one gigawatt. Mid-sized systems would also substantially increase, growing 1837 MW. The availability of cost-effective CHP units for smaller customers is an added benefit of favorable policies and aggressive marketing efforts.

The CHP Challenge would be met in the high case scenario in 2012, assuming that CHP is installed now (1998 through 2000) at the same rate as forecast for 2001. (For a complete analysis of the market for CHP in California refer to the Commission report entitled *Market Assessment of Combined Heat and Power in the State of California*, September 1999.)

What efforts are underway in the U.S. to promote CHP?

The DOE Challenge and other Federal Efforts

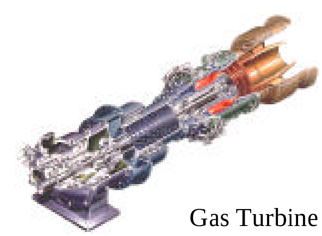
DOE on December 1, 1998 issued the “CHP Challenge”—a program with a goal to double the amount of CHP capacity in U.S. electric power generation by the year 2010, an national increase of 50 GW. The CHP Challenge was launched with an action plan to identify barriers to CHP development, develop new policy and market mechanisms, expand CHP markets, promote advance technologies, leverage technology research and development funds, target CHP in schools and Universities, conduct outreach and education, and showcase prominent developments.

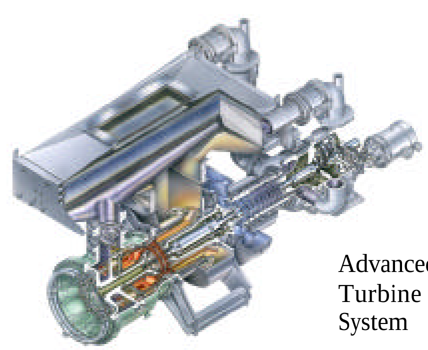
Federal agencies have become involved in the CHP Challenge, including EPA and the Department of Defense. DOE and EPA have been working with the Department of Treasury to review existing depreciation categories for on-site generation equipment. The EPA has made special provision within its NOx Budget Model Rule for allowance set-aside for CHP. The Clinton Administration has proposed an investment tax credit for CHP as part of its electric restructuring proposal. In states across the nation, many energy and economic development offices, environmental protection agencies, and public utility commissions will participate in promoting the goals of the CHP Challenge.

Non-governmental organizations are also involved in promoting CHP. Two organizations recently formed to represent the interests of CHP and distributed generation, the US Combined Heat and Power Association (CHPA) and the Distributed Power Coalition of America (DPCA). Other organizations involved in advocacy for CHP and distributed generation include the International


Microturbine

Turbine systems, from the simplicity of the micro-turbine's one moving part (above) to the advance turbine system of tomorrow (below), are a likely choice for CHP customers of all sizes.


Gas Turbine


Advanced Turbine System

District Energy Association (IDEA), the Gas Research Institute (GRI) and the American Gas Association (AGA).

Resolving Interconnection Issues

The International Institute of Electrical & Electronics Engineers (IEEE) is working to produce a national utility interconnection standard. A special committee of the IEEE will "oversee the development of standards in the areas of Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage, and coordinate efforts in these fields among the various IEEE Societies and other affected organizations to insure that all standards are consistent and properly reflect the views of all applicable disciplines." The IEEE has set an aggressive goal to complete a final draft of interconnection standards by March 2001, to submit to their Standards Board by December 2001. The Interconnection Committee of the California Alliance for Distributed Energy Resources (CADER) is also working to develop a set of uniform interconnection requirements for California in the interim. The goal of the interconnection work is to meet the needs of customers who desire to interconnect, utilities who need to protect their system, manufacturers who wish to design and build equipment to a known standard and energy services companies who wish to participate in the process of interconnection on behalf of customers.

Other Industry Efforts in California

CADER is a coalition of utilities, manufacturers, customer groups, environmental interests and state agencies interested in promoting the installation and operation of small generation plants and other on-site demand-side energy management systems. CADER acts as a clearinghouse for sharing information, building policy consensus, and educating customers and regulators about the benefits of distributed resources, including CHP.

Governmental Efforts in California

The California Public Utilities Commission (CPUC) has issued a decision on an Order Instituting Rulemaking (OIR) proceeding and has called for another to investigate whether current utility rules and regulations unnecessarily impede the development of distributed resources. One goal of the proceeding is to develop recommendations for new policies, rules, or legislation that would remove barriers or promote installation of beneficial technologies such as CHP. The CPUC is jointly managing the proceeding with the Commission and the Electricity Oversight Board. The Commission has been implementing the DOE initiatives for CHP and funding CHP research through its Public Interest Energy Research (PIER) programs.

of excess power will have to compete with these new, low-cost generators.

At the same time, as excess generating capacity is absorbed by the market, the small-to-medium-sized industrial and commercial customers may see their peak electricity rates rise, increasing the value of on-peak use of CHP. Some customers may require the added reliability of CHP while others may be interested in selling CHP reliability services to the grid. In any case, customers who are considering CHP will need to match their internal electric and heat needs with the value of energy in the market to maximize the return on CHP.

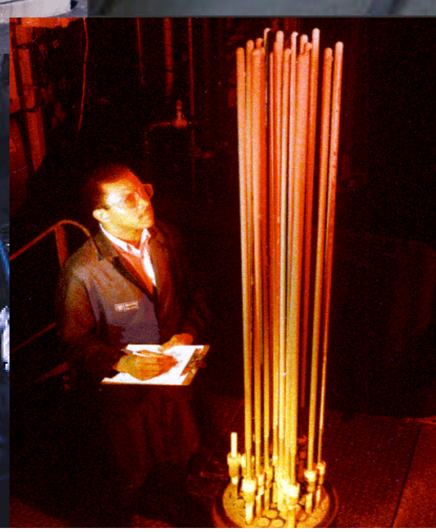
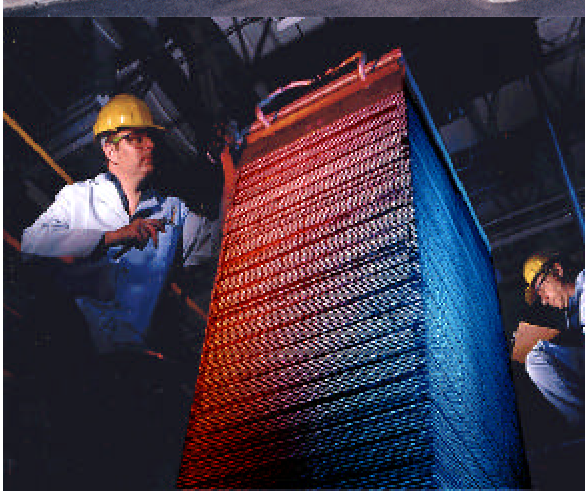
Although wholesale competition and customer electricity prices are an important element in CHP project economics, the true measure of benefit to the customer includes the savings in transmission and distribution costs, increased reliability, and enhanced power quality. These additional benefits may make an otherwise uneconomic CHP project cost-effective. ♦

The 75kW gas microturbine is expected in 2000. Its size, simplicity and decreasing cost could give the microturbine a significant share in the future market for small commercial and industrial facilities.

How can I find out more about CHP?

As mentioned above, there are many governmental and non-governmental organizations currently active in promoting CHP, inside and outside of California. CADER, recently incorporated as a non-profit entity, is perhaps the best starting point in the state for information about CHP. Each of the following websites has additional links and addresses and phone numbers for further information.

American Council for an Energy Efficient Economy (ACEEE)	www.aceee.org
California Alliance for Distributed Energy Resources (CADER)	www.cader.org
California Energy Commission (Commission)	www.energy.ca.gov/distgen
California Public Utilities Commission (CPUC)	www.cpuc.ca.gov/distgen
Department of Energy (DOE)	www.oit.doe.gov/chpchallenge
Distributed Power Coalition of America (DPCA)	www.dpc.org
Environmental Protection Agency (EPA)	www.epa.gov
International District Energy Association (IDEA)	www.districtenergy.org
National Association of Energy Service Companies (NAESCO)	www.naesco.org
Northeast Midwest Institute	www.nemw.org
U.S. Combined Heat and Power Association (CHPA)	www.nemw.org/uschpa
U.S. Fuel Cell Council (USFCC)	www.usfcc.com

The energy source of the future? Instead of burning fuel, fuel cells use electro-chemical processes. They are clean and have limit-less fuel supply: hydrogen.

Clockwise from upper left: Phosphoric Acid fuel cell (PAFC), Proton Exchange Membrane fuel cell (PEMFC), Solid Oxide Electrolyte fuel cell (SOFC) and Molten Carbonate fuel cell (MCFC).

UC San Francisco

In January 1998, the University of California at San Francisco (UCSF) began operation of a combined heat and power system for their medical research university and hospital. The system consists of two Solar® Turbines Taurus™ 60 gas turbines, each driving a 4.16 kV generator, and one 3.75 MW back-pressure steam turbine for combined-cycle operation. The steam turbine is driven off of exhaust heat recovery boilers from the gas turbines. The system has an actual total capacity of 12.1 MW. The system is capable of producing 280,000 pounds per hour of steam at 325° F.

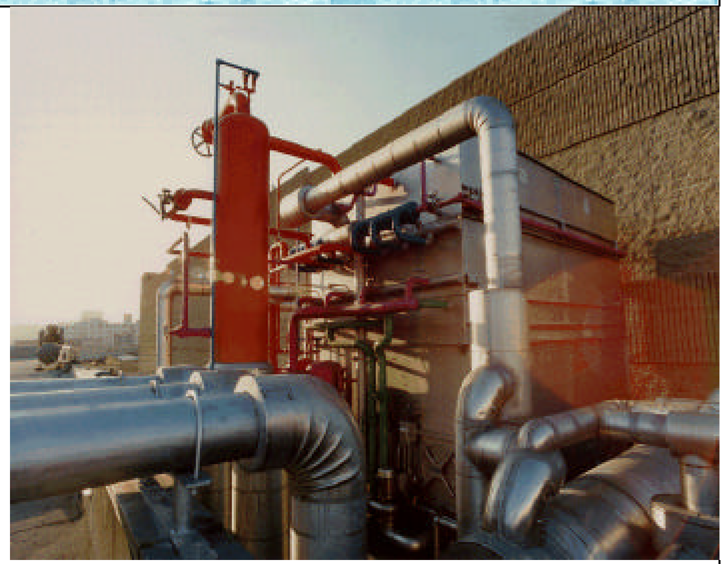
Downstream of the steam turbine additional heat is recovered to provide space heating, ventilation and absorption cooling for the entire facility. The generated electricity serves the hospital critical equipment loads, plug loads, lighting and fan motor loads. The system can run on either natural gas or diesel fuel. Using water injection and selective catalytic reduction, NOx emissions are 5 ppm NOx when running on gas and 8 ppm on diesel, at 15% O2 on a three hour rolling average.

Normally the system runs in parallel with the utility grid, but it has the capability of running on its own if the grid should go down. For emergency operation, the system can supplement the combined cycle combustion turbines with three 2 MW Caterpillar 3516 diesel emergency generator sets. With ten-second start-up time these engines can provide an additional 6 MW of emergency capacity.

In early December 1998, the facility got a chance to test the emergency operations when a grid power failure activated the emergency systems. The Solar turbines and the Caterpillar engines functioned flawlessly, powering the entire hospital, both electric and thermal loads, until the grid functions could be restored.♦

Contact Information: Solar Turbines at 619-544-5352, or www.solarturbines.com.

Los Angeles Cold Storage



From steaming to freezing: The ICRS unit sits atop LA Cold Storage. Shown here are the condenser, absorber and fractionating column.

The Los Angeles Cold Storage facility in downtown Los Angeles is unique among the refrigerated warehouses in California because about 70% of the energy needed to run the facility comes from a CHP absorption compression refrigeration system designed and patented by SIR Worldwide, LLC. The system, called the Integrated Cascade Refrigeration System (ICRS), runs off waste heat from three 500kW Caterpillar G398 TAHCR (turbo-charged after-cooled high compression ratio) gas engines. In typical operating conditions, two of the engines run, the third is on standby. The engines produce electricity to drive rotary screw and reciprocating compressors to pump refrigerant to the freezer coils. The remaining 40% of power produced runs fans, lights, computers and battery chargers for electric forklifts and auxiliary equipment. Waste heat is recovered out of the engine exhaust and engine jacket water. The 7 million Btus of heat that are recovered deliver 3 million Btus of refrigeration through an ammonia absorption and compression system that enhances efficiency and capacity of the refrigeration equipment. Los Angeles Cold Storage Company was founded in 1895 and presently has about 8 million cubic feet (about 400,000 square feet) of -10° F storage space in four plants. ♦

Further information on the ICRS CHP refrigeration unit may be obtained from the patent holder SIR Worldwide, LLC at 213-626-5885, by internet at www.sirworldwide.com or from LA Cold Storage at 213-624-1831.

UC Los Angeles

Aerial view looking west at the UCLA Energy Systems Facility on the Westwood Campus of UCLA.

In the early 1980's, UCLA needed to upgrade its campus energy system with a new chilled-water system. The school had already completed an assessment of a project to install self-generation equipment, it was not cost effective until they considered the additional efficiencies to be gained using CHP. Today, steam is delivered to more than 100 campus buildings through the existing piping infrastructure and chilled water is distributed to 18 campus buildings at 42 degrees F through about 6.5 miles of new installed underground piping.

The system is driven by a pair of 14.5 MW combustion turbine generators. The exhaust gases from the combustion turbines are directed to a pair of heat recovery steam generators (HRSG) with

UC Los Angeles

supplementary natural gas firing. The steam generators produce steam at 660 psig and 750 degrees F. The high-pressure steam drives a condensing steam turbine electric generator to produce 48 MW of electricity. The cooling system relies on two steam turbine-driven centrifugal chillers and one electric driven chiller. Four single stage absorption chillers use exhaust steam from the steam turbine chillers to produce additional chilled water for the campus distribution loop. The gas turbines run on landfill gas, which would otherwise be flared and wasted, supplemented by natural gas. Emission controls keep NOx emissions under 6 ppm. The system was completed in 1994 and serves 13.5 million square feet of campus space with low cost, reliable electrical and thermal energy. ♦ *Contact Information: 310-825-3402*

Pumps circulate chilled water through 6.5 miles of underground pipe to serve 18 buildings at UCLA.

Santa Barbara County Jail

In the early 1990's, Southern California Gas Company purchased ten 200kW ONSI phosphoric acid fuel cells (PAFCs) as part of a demonstration program. These were among the first commercially available PAFCs in the world. One of the customers chosen to participate in the program was the Santa Barbara County jail. The fuel cell was and installed and became operational in October 1994. Since that date, it has run for 27,000 hours, 62% availability factor.

Fuel cells run on hydrogen and since there is no free-standing hydrogen in the environment it must be created from a source fuel. The ONSI PAFC uses natural gas as the source fuel, from which it extracts hydrogen for use in the cell. This requires a temperature in excess of 1400° F. When the cell is first started the reformer must come up to temperature by burning natural gas for about 1½ hours. Then hydrogen begins to flow to the cell stack which begins to produce current, at which point the reformer stops burning natural gas and begins using part of the freed hydrogen to keep up temperature. To avoid this bootstrapping procedure except after annual maintenance, the SB County fuel cell, like other PAFCs, runs around the clock. Heat is recovered by the system heat exchanger in the form of hot water that serves the kitchen, the showers and the condensate return space heating system. This thermal load is insufficient to take up all the hot water produced when the fuel cell is operating at full load, so this particular fuel cell runs at just 25% of capacity, or 50kW. The electricity produced serves a portion of the electrical needs of the facility. It is not dedicated to any of these loads, so if the grid goes down, the system as configured does not provide emergency support, but goes into idle mode. The fuel cell requires check maintenance every 3000 hours and full maintenance, including three- to four-day shutdown, every 12,000 hours. ♦ *For further information call SoCalGas at 800-GAS-2000.*